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USER'S GUIDE

MODEL: 0C60A

PART NO. : CS14-2417

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USER'S GUIDE

MODEL: OC60A

PART NO. : CS14-2417

DANGER HIGH VOLTAGE

WARNING: This publication describes a product engineered and designed to supply HIGH VOLTAGE. Accordingly, maximum safeguards have been built into the equipment and the best safety techniques possible are set forth in the unit's operating instructions. These instructions contain cautions, warning the user to exercise great care in the use of certain controls and at appropriate points in the operating procedures. Despite these written warnings the operator of this equipment is nevertheless strongly advised to maintain a safety consciousness at all times. The following rules are particularly relevant and must be followed at all times.

BEFORE CONNECTING INPUT POWER, GROUND CASE.

BEFORE UNGROUNDING CASE, DISCONNECT POWER.

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I SCOPE

This publication describes the HIPOTRONICS "A" (Automatic series of portable Liquid Dielectric Testers (LDTs). It is intended to provide a simplified reference for users of this equipment, and to allow them to use its features quickly, safely and efficiently.

Information in the body of this publication applies to all "A" models of portable LDTs: OC60A and OC90A. Information pertaining to the specific model purchased is provided in the pocket of this publication. This includes a diagram of the control panel, a PCB assembly diagram, a Parts List and a schematic diagram. If one or more Test Cells (oil cups) are shipped with your model, the applicable ASTM standard will also be included.

The publication contains four major sections: General Description, Set-Up Instructions, Operation Instructions and Special Operations.

The General Description section describes the major features of the "A" models in the portable LDT series and also contains a description of the functions performed by each of the controls and indicators on the control panel.

The Set-Up Instructions section provides step-by-step instructions for set-up of the unit prior to beginning testing operations.

The Operation Instructions section provides step-by-step instructions for performing liquid dielectric strength tests.

The Special Operations section describes the procedures involved in Recalibration and Trouble Shooting.

II REFERENCES

It is assumed that the user has a basic understanding of the handling of electrical equipment and the major functions to be performed by the equipment to be used. An outline of the functions, features and specifications of HIPOTRONICS Portable Liquid Dielectric Testers is provided in HIPOTRONICS Brochure HP7106. Valuable information is also contained in the American Society for Testing Materials (ASTM) Standards D1816 and D877.

A copy of ASTM Standard D877 is supplied with orders of the TC/DE Test Cell; a copy of ASTM Standard D1816 is supplied with orders of the TC/VDE Test Cell. Copies of both ASTM Standards are supplied with the TC/CE90, which is designed specifically for use with Model OC90A.

III GENERAL DESCRIPTION

This section is intended to acquaint the user with the major features of the models in the HIPOTRONICS "A" series of portable Liquid Dielectric Testers (LDTs) and the functions performed by each of the controls and indicators on the control panel.

IV FEATURES AND SPECIFICATIONS

The HIPOTRONICS portable LDTs are designed to test the breakdown voltage of insulating liquids used in the high voltage field as the insulating and cooling medium in cables, transformers, oil circuit breakers and similiar apparatus. They meet all ASTM requirements for performing these tests as described in ASTM Standards D877 and D1816, as well as IEC 156.

The portable LDT "A" series consists of the following models: OC60A and OC90A. They are fully automatic, providing output voltage ranges of 0-60 kV and 0-90 kV, respectively.

Table 1 lists the two automatic models, along with the specifications unique to each model. Note that output voltages indicated are from center-tapped transformers, e.g., the OC60A provides maximum output of 60 kV rms between two bushings, 30 kV per bushing to ground.

MODEL	OUTPUT @ 2 kVA	METER RANGE (kV ac Scale)	RATE OF RISE
OC-60A	0-60 kV rms	0-60	500/2000/3000 VPS (AUTOMATIC)
OC-90A	0-90 kV rms	0-100	500/2000/3000 VPS (AUTOMATIC)

Table 1 Automatic Portable Liquid Dielectric Testers

INPUT

All models operate from an input of 115 volts ac, 50/60 Hz, single phase, 15 amps, (or optionally 220/2440 V, 5 A) and are equipped to perform both DE and VDE testing. All Models feature automatic rate of rise of 500 and 3000 volts per second with manual dwell at any voltage. Other features include memory voltmeter and overload read switch. A variety of Test Cells (oil cups) are available for use with the HIPOTRONICS portable LDTS. They are as follows:

TC/DE TEST CELL

This Test Cell is for use with LDT model OC60A for testing at 3000 volts per second in accordance with ASTM Standard D877. This ASTM Standard, as well as a specification sheet for the TC/DE itself, is supplied with the item.

TC/VDE TEST CELL

This Test Cell is also for use with LDT model OC60A for testing at 500 volts per second in accordance with ASTM Standard D1816. This ASTM Standard, as well as a specification sheet for the TC/VDE itself, is supplied with the item.

IC/IEC TEST CELL

This test cell is for use with LDT Model OC60A for testing at 2000 volts per second in accordance with IEC-156 standard.

TC/CE90 TEST CELL

This special combination Test Cell is provided for use only with LDT OC90A, and has interchangeable DE and VDE electrodes that permit testing at 3000 volts per second or 500 volts per second, in accordance with ASTM Standards D877 and D1816. These ASTM Standards, as well as a specification sheet for the TC/CD90 itself, is supplied with the OC90A.

V CONTROLS AND INDICATIORS

A diagram of the Control Panel for your particular model in the LDT "A" series is contained in the back pocket of this publication. This diagram should be referred to as well as the actual control panel when reading the description that follows and when following the various instructions. The Control Panel's controls and indicators, their functions and use, are described below.

A) VOLTMETER

The voltmeter is located in the window at the top of the control panel, and indicates the ac output voltage in kilovolts, as indicated by the label "ac kV" on the scale. The screw below the meter is used to adjust the meter to zero.

The voltmeter is certified accurate to 2% and is provided with a memory feature. The memory feature will cause the indicator to retain its settings at the breakdown voltage until manually reset, even when output voltage has been turned off.

The voltmeter scale varies with each model. The scale readings are 0-60 on the OC60A and 0-100 on the OC90A.

B) RATE/RISE SWITCH

Output voltage is regulated by means of the RATE/RISE rotary switch.

When the START button is depressed, the output voltage will increase at a rate of 500, 2000, Or 3000 volts per second depending on the position of the RATE/RISE rotary switch. The STOP settings provide a manual dwell capability, i.e., voltage output may be maintained at any achieved level.

C) START BUTTON

The START button is used to initiate the application of output voltage. Voltage applied will depend on the RATE/RISE switch setting described above. Once the START button is depressed, voltage will be applied continuously until breakdown voltage is achieved and the red FAILURE signal glows, or until the HV OFF ANYTIME interlock switch is de-activated by opening the safety glass cover. The test may also be aborted by depressing the RESET button.

D) FAILURE INDICATOR

The FAILURE indicator is a red bulb that glows when the breakdown voltage of the insulating liquid is reached. Output voltage is automatically turned off at the moment of arc-over (breakdown voltage).

E) RESET BUTTON

The RESET button, located beneath the FAILURE indicator, is used to turn off the FAILURE indicator, reset the voltmeter to zero, and permit the resumption of testing. It will not, however, cause output voltage to be re-applied, as this can be done following breakdown only by depressing the START button. It will abort an in-process test and reset all circuits to initial condition.

F) AC POWER CONTROLS

The section of the control panel labeled "AC POWER" consists of a group of three controls. On the left is the toggle switch to turn the ac power ON and OFF. (The switch is ON in the upper position.) The white bulb in the center is the ac power indicator which glows when the unit is ON. A 5 amp fuse is on the right of this group and may be accessed for replacement by depressing the black cap and turning it counter-clockwise.

G) HV OFF ANYTIME SWITCH

The application of high voltage may be terminated at anytime by use of the high voltage test cage interlock switch (above HV OFF ANYTIME label). This is accomplished on the OC60A by depressing the switch manually or by sliding open the safety glass cover. On the OC90A, lifting the safety glass cover will stop the application of high voltage by releasing the interlock switch. NOTE: The interlock switch operates in reverse on the OC90A. (Switch is ON when depressed, OFF when released.)

VI SET-UP INSTRUCTIONS

The "A" series of portable LDTs require no special installation procedure. The units are shipped ready for use, with the power cord and plug as well as any test cells (oil cups) packed inside the test cage under the safety glass cover, which is taped in a closed position.

The procedures for set-up of the unit prior to beginning testing are as follows:

1. Remove packing material, power cord and plug, test cells and any other packed components from test cage.

2. Ground unit before connecting input power. (Ground lug is located on left side of unit below plug receptacle.)

3. Insert socket end of power cord into receptacle on left side of unit, and connect to suitable power source. If a two-prong adapter is used, be sure to ground pigtail.

4. Secure the desired quantity of the insulating liquid to be tested, and ensure that the temperature is between 20-30 degrees Centigrade (68-86 degrees Fahrenheit).

5. Wipe electrodes and test cell clean with dry, lint-free tissue paper or clean, dry chamois.

6. Check and adjust spacing of electrodes in test cell to ensure conformity with ASTM Standard (D877 and D1816). Use appropriate gap gauge to adjust electrode spacing. Pre-tested gauges are supplied with Hipotronics Test Cells.

7. Rinse electrodes and test cell thoroughly with a dry, hydrocarbon solvent such as kerosene, Freon or Stoddard solvent.

8. After thorough cleaning, flush out the test cell with a filtered sample of the type of liquid to be tested.

9. Perform a breakdown test on a sample of the liquid to be tested, following the procedures described in the section, "Operation Instructions."

10. If the breakdown voltage of the sample liquid is in the proper range for this type of liquid (refer to manufacturer's specifications for breakdown range), proceed to Step 12.

11. If the breakdown voltage of the sample liquid is not in the proper range, empty test cell and repeat Set-Up Instructions from Step 5. If Set-Up Instructions have already been repeated unsuccessfully, repeat again from Step 5 using an insulating liquid at Step 9 whose breakdown voltage is beyond question. If this breakdown test shows the proper range, then the insulating liquid to be tested should be rejected. If the test does not show the proper range, the user should then recalibrate the LDT as described in the section, "Recalibration."

12. Following a successful sample breakdown test, empty the test cell and immediately refill it with a sample of the insulating liquid to be tested. Swirl the oil several times in the test cell to mix any impurities present with the oil, and empty the cup. The LDT and test cell are now ready for testing as described in the section, "Operation Instructions."

VII OPERATION INSTRUCTIONS

This section provides step-by-step instructions for testing the breakdown voltage of insulating liquids using the HIPOTRONICS "A" series of portable Liquid Dielectric Testers. Prior to following these instructions, the procedures described in the preceding section, "Set-Up Instructions," must be performed.

1. Ensure that unit is properly grounded before connecting input power. (Ground lug is located on left side of unit below plug receptacle.)

2. Ensure that power cord is properly plugged in as described in Step 3 of "Set-Up Instructions."

3. Re-check and adjust spacing of electrodes in test cell to ensure conformity with ASTM Standards (D877 or D1816). Use appropriate gap gauge to adjust electrode spacing. Pre-tested gauges are supplied with HIPOTRONICS test cells.

4. Fill test cell with a sufficient quantity of the insulating liquid to completely cover the electrodes, and to the minimum level specified in the appropriate ASTM Standard.

5. Swirl the insulating liquid by rocking the test cell slowly. Swirl gently, as rapid agitation may create an excess of air bubbles in the liquid.

6. Gently snap the filled test cell in place between the bushings of the transformer in the test cage, and close the safety glass cover.

7. Allow the sample to stand for a minimum of three minutes, to permit any accumulated air bubbles to escape before testing. If VDE test cell is used, plug line cord into receptacle on left panel of test cage.

8. Turn AC POWER "ON".

9. If FAILURE indicator is on, depress RESET button until voltmeter reading is at "0".

10. Check to ensure voltmeter reading is at "0", and set RATE/RISE rotary switch to appropriate setting.

11. Depress START button to initiate test. Voltage will be applied automatically at specified rate until breakdown occurs, at which point FAILURE indicator will glow and voltage will be turned off.

    NOTE: Voltage may be terminated before breakdown by deactivating test cage interlock switch (HV OFF ANYTIME) by opening safety glass cover. Alternatively, voltage may be maintained at any level prior to breakdown (manual dwell) by setting RATE/RISE switch to center (STOP) position.

12. Voltmeter will continue to register breakdown voltage until RESET button is depressed. After reading and recording breakdown voltage, depress RESET button and allow voltmeter to return to "0".

13. Perform repetitive breakdown tests beginning at Step 11 in accordance with statistical criteria described in appropriate ASTM Standard.

VIII SPECIAL OPERATIONS

This section describes the step-by-step procedures required to perform special operations incidental to the function of insulating liquid testing performed by HIPOTRONICS' "A" series of LDTs. These special operations are Recalibration and Trouble Shooting.

Special operations should be performed only by a trained technician, as they require access to the power supply (test cage) section of the unit, where dangerously high voltage may be present.

A) RECALIBRATION

Recalibration may be performed by the user on OC60A units. Special care is required to recalibrate OC90A units, and users are cautioned to contact HIPOTRONICS' Service Department (914-279-8091) before attempting to recalibrate units of this model.

The OC60A contains four potentiometers (pots) that are used for calibration. One pot is used to calibrate the voltmeter, and the other three pots are used to calibrate the RATE/RISE speed settings.

1) RECALIBRATION PREPARATION

Before attempting to recalibrate the OC60A, the user should prepare the unit as described in the two sections below:

a) VOLTMETER

1. Place the unit on a table or platform at a level that will allow for maximum accuracy in readings.

2. Ensure that AC POWER switch and RATE/RISE switch are in OFF positions.

3. Ground case before connecting input power. A ground lug is located for this purpose below the power cord receptacle on the left side panel of the unit.

4. If HIPOTRONICS Model OCCM Standard Meter is used for calibration proceed directly to "VOLTMETER RECALIBRATION". Otherwise continue with following step.

5. Remove the three screws along the front top edge of the unit. These screws secure the track in which the safety glass cover slides. Remove the track and lift the safety glass cover out. Caution: With the safety glass removed the High Voltage section is exposed. Consequently, the user is advised to use extreme caution in this situation.

Proceed to "VOLTMETER RECALIBRATION".

b) RATE OF RISE

1. Place the unit on a table or platform at a level that will allow for maximum accuracy in readings, and will also provide space to rest the left side panel alongside the unit.

2. Ensure that AC POWER switch and RATE/RISE switch are in OFF positions.

3. Ground case before connecting input power. A ground lug is located for this purpose below the power cord receptacle on the left side panel of the unit.

4. Remove screws attaching left side panel to unit. There are nine screws in all: three on the left side of the control panel, two on each side of the side panel, and two on the bottom of the side panel.

5. Insert power cord plug into side panel receptacle, and reset side panel (outer side down) across power cord on table. (Top edge of panel should face rear of unit to avoid pulling wires that lead from inner portion of receptacle.

B) VOLTMETER RECALIBRATION

HIPOTRONICS' voltmeters have been calibrated with standards traceable to national standards maintained by the National Bureau of Standards in Washington D.C., and are certified accurate to within 2% when shipped.

Meter recalibration should be performed by the user as often as necessary to meet the requirements of each particular installation, as dictated by usage and by the user's standards for accuracy. Considering these requirements, how frequently meter recalibration should be performed depends primarily on three factors: amount of physical handling, time lapse and extent of usage. Intervals between meter recalibration may vary anywhere between one month and one year.

The procedures involved in recalibrating the OC60A voltmeter are as follows:

1. Proceed only if the Recalibration Preparation for the voltmeter has been performed (page 7).

2. Connect power cord to suitable source. If a two-prong adapter is used, be sure to ground pigtail.

3. A calibration standard meter is available (HIPOTRONICS' Model OCCM) that replaces the oil cup. With this meter a minimum of safety hazard is realized along with a maximum of convenience. If used skip to Step 8, if not used continue with next step.

4. Select calibrated external voltmeter with maximum meter range of approximately one-half (1/2) of unit's maximum output. (Because the high voltage transformer in these units has a grounded center tap, only one-half of the rated voltage is applied to each output bushing.)

5. Connect low side (ground) of external voltmeter to ground lug on unit's left side panel.

6. Separate the two bushings inside the test cage with insulation to prevent arcing when voltage is applied.

7. Using connector with heavily insulated wire, connect one bushing inside test cage to high side of external voltmeter. (HIPOTRONICS' Quality Control Department tests both bushings before shipping. These procedures require testing only one bushing, as it is considered highly unlikely that the voltage output of the bushings will differ.)

8. Turn AC POWER switch ON.

9. Determine the calibration value (voltage readings) to be measured. It is suggested that approximately two-thirds (2/3) of the unit's capacity be used as the calibration value, i.e., 40 kV for Model OC60A and 60 kV for Model OC90A.

10. Turn RATE/RISE toggle switch up to "500 vps" setting.

11. Apply output voltage by depressing START button.

12. Turn RATE/RISE switch to STOP setting as soon as reading on external meter equals one-half (1/2) of calibration value determined in Step 8. (If suggested values of 34 kV or 40 kV were used, then RATE/RISE switch should be turned to STOP setting when external meter reading reaches 17 kV or 20 kV for Model OC60A.

13. Check reading on unit meter. If unit meter reading does not equal calibration value determined in Step 9, meter calibration potentiometer (pot) labeled "VM CAL" on front panel must be adjusted. The "VM CAL" should be turned slowly with an insulated screwdriver until voltmeter reading is at desired point.

14. Calibration of meter is now complete. Flip AC POWER switch OFF, and RATE/RISE switch to STOP.

15. If necessary, reinstall track and safety glass cover. Slide cover all the way to the right and ensure that the test cage interlock switch comes up through the notched corner of the safety glass.

16. If RATE/RISE speed settings are to be recalibrated, perform "Preparation" (page 8).

3) RATE/RISE RECALIBRATION

RATE/RISE speed setting potentiometers (pots) are located on the Printed Circuit Board (PCB) assembly. They are labelled LOW and HIGH to indicate the related switch setting.

Procedures for recalibrating the RATE/RISE speed settings are as follows:

1. It is recommended to the user that the voltmeter be recalibrated before the RATE of RISE.

2. Ensure that the RATE of RISE Recalibration Preparation has been performed (page 8).

3. Connect power cord to a suitable source. If a two-prong adapter is used, be sure to ground pigtail.

4. Obtain accurate timer (stop-watch or watch with sweep-second hand) to monitor speed of RATE/RISE settings.

5. Flip AC POWER switch ON.

6. Set RATE/RISE switch to speed setting that will be calibrated. All speed settings must be recalibrated separately, but may be recalibrated in any order.

7. Depress the START button and measure the time it takes to go from 10 kV to the final value as shown in Table 2 below. Compare the measured time with that in Table 2 and adjust the appropriate pot as necessary.

TABLE 2

Rate/Rise	Final Value (kV)	Time(s)	Pot
500	20	20	R1
2000	30	10	R2
3000	40	10	R28

As noted previously, the user is cautioned to use a well-insulated tool to adjust pots and avoid physical contact with any component of the unit.

8. Calibration of RATE of RISE should now be complete. Reassemble unit.

B) TROUBLE SHOOTING

All products shipped by HIPOTRONICS are thoroughly tested against a rigid set of standards by the firm's Quality Control Department. In the event a unit appears not to function upon delivery, the user is referred to the section, "Returned Material."

The Trouble Shooting section of the publication is intended to aid the user in locating the source of a problem when an OC60A unit is either not functioning or functioning improperly. Do not attempt to trouble-shoot problems on OC90A units. Contact HIPOTRONICS' Service Department to correct problems with OC90A units.

Use of these procedures is at the user's own risk. It is not recommended that these procedures be used while the equipment is under Warranty, as some of the recommended steps may result in voiding the Warranty.

These procedures are intended for use only by a trained repair technician, and are not recommended for use by individuals trained only to operate the equipment.

The trouble-shooting guide that follows lists in tabular form the most commonly encountered problems. Listed to the right are symptoms of the problem and to the left, possible causes and corrective action. If a problem arises of more complexity, the "DESCRIPTION OF CIRUCIT OPERATION" AND "TEST OPERATION" sections that follow, along with the enclosed schematics should provide the experienced technician with additional useful information.

1) TROUBLE SHOOTING TABLE

PROBLEM	POSSIBLE CAUSE & CORRECTIVE ACTION
NO HIGH VOLTAGE OUTPUT	a) Fuse has blown; replace fuse. b) Low inupt voltage. Connect to suitable voltage source. c) Variac (T1) damaged. Replace if necessary. d) Motor advances but variac (T1) doesn't. Realign motor shaft with variac and tighten down shaft.
ERRATIC HIGH VOLTAGE	a) Variac brushes are worn or dirty. Clean or replace brushes.
INCORRECT VOLTMETER READING	a) Excessive use or vibration. Recalibrate to a standard meter. b) Meter has accumulated static charge. Apply anti-static spray.
HIGH VOLTAGE RISES AT SAME SPEED REGARDLESS OF RATE OF RISE SELECTED	a) IC-1 (CD4066BE) faulty. Replace.
MOTOR WILL NOT RUN AT ALL	a) IC-1 (CD4066DE) faulty. Replace. b) IC-3 (SAA1027) faulty. Replace. c) IC-2 (NE555V) faulty. Replace. d) Check for 12 V on power supply board (60-541), replace voltage regulator chip if necessary (LM340T-12)
FAILURE LIGHT INDICATION NOT CONSISTENT WITH NORMAL MODE OF OPERATION	a) Faulty SCR-1 (C106D2) on the relay circuit board (30-542). Replace.

B) DESCRIPTION OF CIRCUIT OPERATION

The OC60/90 Liquid Dielectric Tester employs a solid state stepper motor drive to raise (lower) the output voltage of an auto-transformer. This output is stepped up through an epoxy cased HV Transformer to the required test voltage. The logical operation of the OC60/90 is implemented by a combination of relays and solid state electronics. There are two internal dc power sources; a 170 V peak rectifier formed by R1,R2, CR1 and C1 located on the relay board (30-342) to operate the HV ON Relay RY1 and overload relay RY2; and a +12 V regulated power supply (30-541) to operate the motor drive circuitry.

The Motor Drive incorporates a stepper motor which is sequenced by IC-1 (SAA1027) Driver Chip. Voltage at Pin 3 of this IC controls the direction of rotation. High State (+12 V) will raise (C.W. from top of Motor Drive) and Low State (OV) will lower (CCW) the autotransformer. The step rate is provided to Pin 15 by a solid state clock IC2 (NE555). This clock signal may be monitored at the test point provided on the circuit board. The clock rate is determined by the charging time of C1 and the related charging circuitry. A CMOS quad analog switch, IC-1 (CD4066DE) will provide a charging path through R1, R3 (500 V.P.S.) R2, R4 (2000 V.P.S.), or R28, R29 (3000 V.P.S.) for rate of rise selection, through R5 for return to zero rate or it will pull C1 to ground to implement the hold (stop) function. R1-12, CR1-3 and C6-8 provide input protection for the CMOS chip.

There are two photo interrupters mounted on the underside of the motor drive board (30-540) which act as the upper and lower limit switches. When the upper limit is reached, the actuator flag will turn off the transistor half and bring the voltage across R23 to a minimum (near ground). This turns off the CMOS switch (IC-1) and keeps C1 from charging, effectively stopping the motor.

The Lower limit photo interrupter is energized only when the down function is implemented (Reset). This develops - 12 V across R6 which switches on the CMOS switch and stops the motor.

There is a compensation network R18-20, C2 which varies the clock rate depending on the voltage from the unregulated power supply (30-541). This allows for a constant HV output rate of rise with varying ac line input. This circuit is rarely a problem and can be checked experimentally. The resistor R20 adjusts the degree of compensation.

3) TEST OPERATION

The test operation begins by depressing the start button. RY1 pulls in; ac voltage is applied to the HV transformer from the variac via RY1A, +12 V goes to PIN 3 of IC-3 via RY1C to implement the "UP" function and RY1B closes to latch RY1 on.

Output voltage will rise at a rate selected by the front panel control S4 and will continue to rise until a breakdown occurs.

The Overload sensing is done by a Reed relay and its energizing coil which is in series with the HV transformer primary. When a breakdown occurs, K1 pulls in momentarily and applies dc voltage to the gate of SCR-1. SCR-1 conducts and energizes RY2 contact; RY2A latches RY2, lights the fail light, resets the SCR and turns off dc power to RY1. Contact RY2 implements the "Hold" function on the motor drive board (holds breakdown voltage reading).

The Reset button releases RY2. The "Hold" function is released and the auto-transformer will return to zero. The reset button, and its series companion, the interlock switch, have priority and will stop or reset a test at any time.

The "START" button can now be pressed to initiate a new test cycle.

WARRANTY

HIPOTRONICS, INC. warrants to the orginal purchaser of any new merchandise that the merchandise is free from defects in material and workmanship under normal use and service for a period of one year from the date of shipment. The obligation of Hipotronics, Inc. under this Warranty is limited, in its exclusive option, to repair, replace or issue credit for parts or materials which prove to be defective, and is subject to Purchaser's compliance with the Hipotronics, Inc. Warranty Claim Procedure as set forth below. The happening of any one or more of the following events will serve to void this Warranty and any defect or damage resulting therefrom is specifically excluded from Warranty coverage: (a) defects due to accident, negligence, alteration, modification, faulty installation by Purchaser or Purchaser's agents or employee, abuse or misuse; (b) attempted or actual dismantling, disassembling, service or repair by any person, firm or corporation not specifically authorized in writing by Hipotronics, Inc. (c) defects caused by or due to handling by carrier, or incurred during shipment, transshipment or other move.

This Warranty covers only those parts and/or materials deemed by Hipotronics, Inc. to be defective within the meaning of this Warranty. The liability of Hipotronics, Inc. shall be limited to the repair, replacement or issuance of credit for parts deemed defective within the meaning of this Warranty. Costs incurred by purchaser for labor or other expenses incidental to the inspection, repair, replacement or issuance of credit for such parts and/or material shall be the sole responsibility of purchaser. This Warranty shall not apply to any accessories, parts, or materials not manufactured or supplied by Hipotronics, Inc. and if, in the sole discretion of Hipotronics, Inc., Purchaser's claim relates to any materials or workmanship manufactured or performed by the supplier of a component part, or of the manufacturer of a device of which the defective part is a component, Hipotronics, Inc. reserves the right to disclaim liability under this Warranty and to direct that the Purchaser deal directly with such supplier or manufacturer. Hipotronics, Inc. agrees to assist the Purchaser in processing or settling any such claim without prejudicing its position as to liability.

WARRANTY CLAIM PROCEDURE

Compliance with the following Warranty claim Procedure is a condition precedent to the obligation of Hipotronics, Inc. under this Warranty:

a. Purchaser must notify Hipotronics, Inc. in writing by certified or registered mail, of the defect claimed within twelve months after date of original shipment. Said notice shall describe in detail the defect, the defective part, and the alleged cause of defect.

b. At the exclusive option of Hipotronics, Inc., Purchaser shall dismantle or disassemble at Purchaser's cost and expense and shall ship the defective part or material prepaid to Hipotronics, Inc., Brewster, New York 10509, for inspection, or permit an authorized service representative of Hipotronics, Inc. to inspect the defective part or material at Purchaser's premises. If Hipotronics, Inc. shall inspect the part or material at the Purchaser's premises, Purchaser shall provide facilities for, and at Purchaser's cost and expense, dismantle, disassemble, or otherwise make accessible the subject part or material whether or not same is a component of or installed in a device other than that manufactured or supplied by Hipotronics, Inc. If disclosure shows that the defect is not one for which Hipotronics, Inc. is liable, the Purchaser agrees to reimburse Hipotronics, Inc. for all expense incurred.

c. Upon receipt of the defective part or material, or after access to same, Hipotronics, Inc. shall inspect the part or material to determine the validity of Purchaser's claim.

The validity of any Warranty Claim, Purchaser's compliance with Hipotronics, Inc. Warranty Claim Procedure, the obligation to either repair, replace, or issue credit, or direct the purchaser to deal directly with a manufacturer or supplier are to be determined solely and exclusively by Hipotronics, Inc. and any determination so made shall be final and binding.

THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED ON THE PART OF HIPOTRONICS, INC., INCLUDING THE WARRANTIES OF MECHANTABILITY AND FITNESS FOR USE, AND CONSEQUENTIAL DAMAGES ARISING FROM ANY BREACH THEREOF AND HIPOTRONICS, INC. NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON, FIRM OR CORPORATION TO ASSUME ANY LIABILITY OR OBLIGATION IN CONNECTION WITH THIS SALE ON ITS BEHALF AND PURCHASER ACKNOWLEDGES THAT NO REPRESENTATIONS EXCEPT THOSE MADE HEREIN HAVE BEEN MADE TO PURCHASER.

RETURNED MATERIAL

If, for any reason, it should become necessary to return the equipment described in this publication to the factory, the Warranty Service Department of Hipotronics must be contacted, at which time the following data must be given in order that we may identify the unit and determine the necessity for return. (Tel. (914) 279-8091) MODEL, SERIAL NO. and TYPE (Part No) is indicated on the black and silver tag affixed to the unit.

MODEL:
SERIAL NUMBER:
TYPE (Part No):
REASON FOR RETURN:
DEFECT:
ALLEGED CAUSE OF DEFECT:

If Hipotronics deems return of the unit appropriate, an "Authorization for Return" tag will be issued. This will instruct you as to the method of return. The pink copy is for your records, the hard copy to be affixed to the unit being returned. If return is not deemed advisable, other inspection arrangements will be made.

NOTE: Material received at this point without the proper authorization shall be held as "customer's property," with no service performed until such time as the proper steps have been taken.

Your cooperation is requested in order to ensure prompt service. Thank you.

PARTS ORDERING

To order replacement parts of this unit, please refer to the Parts List contained in the pocket of this publication. The number of the specific component is required, along with the TYPE (Part No) of the unit. The TYPE (Part No) is indicated on your Parts List, and on the black and silver tag affixed to the unit.

Designation: D 877 – 87

Method 5702—Federal Test Method Standard No. 791b

AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for DIELECTRIC BREAKDOWN VOLTAGE OF INSULATING LIQUIDS USING DISK ELECTRODES[1]

This standard is issued under the fixed designation D 877; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This test method covers a referee and a routine procedure for determining the dielectric breakdown voltage of insulating liquids. These procedures are applicable to liquid petroleum oils, hydrocarbons, and askarels commonly used as insulating and cooling mediums in cables, transformers, oil circuit breakers, and similar apparatus. The referee procedure, with modifications, is suitable for testing silicone fluids (see Methods D 2225). The referee procedure is also suitable for testing alkylbenzenes. The suitability of either the referee or the routine procedure for testing liquids having viscosities exceeding 900 cSt (mm^2/s) (5000 SUS) at 40°C (104°F) has not been determined.

1.2 This test method is recommended for acceptance tests on unprocessed insulating liquids received from vendors in tank cars, tank trucks, and drums. It may also be used for the routine testing of liquids from power systems apparatus rated 230 kV and below.

1.3 This test method is not recommended for testing filtered, degassed, and dehydrated oil prior to and during the filling of power systems apparatus rated above 230 kV, or for testing samples of such oil from apparatus after filling. Test Method D 1816 is more suitable for, and is recommended for, testing such oils.

1.4 Both the SI and inch-pound units are equally acceptable.

1.5 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 484 Specification for Hydrocarbon Dry-cleaning Solvents[2]

D 923 Methods of Sampling Electrical Insulating Liquids[3]

D 1816 Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes[3]

D 2225 Methods of Testing Silicone Fluids Used for Electrical Insulation[2]

2.2 *Institute of Electrical and Electronics Engineers Standard:*

No. 4 Measurement of Voltage in Dielectric Test[4]

3. Significance and Use

3.1 The dielectric breakdown voltage of an insulating liquid is of importance as a measure of the liquid's ability to withstand electric stress without failure. It serves to indicate the pres-

[1] This test method is under the jurisdiction of ASTM Committee D-27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.05 on Electrical Test.

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[2] Discontinued; see *1984 Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 10.03.

[4] Available from The Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th St, New York, NY 10017.

ence of contaminating agents, such as water, dirt, moist cellulosic fibers, or conducting particles in the liquid, one or more of which may be present in significant concentrations when low dielectric breakdown values are found by test. However, a high dielectric breakdown voltage does not indicate the absence of all contaminants; it may merely indicate that the concentrations of contaminants that are present in the liquid between the electrodes are not large enough to deleteriously affect the average breakdown voltage of the liquid when tested by this method. See Appendix X1.

4. Apparatus

4.1 *Transformer*—The desired test voltage may be most readily obtained by a step-up transformer energized from a variable low-voltage commercial power frequency source. The transformer and controlling element shall be of such size and design that, with the test specimen in the circuit, the crest factor (ratio of maximum to mean effective) of the 60-Hz test voltage shall not differ by more than ±5 % from that of a sinusoidal wave over the upper half of the range of test voltage. The crest factor may be checked by means of an oscilloscope, a sphere-gap, or a peak-reading voltmeter in conjunction with a root-mean-square voltmeter. Where the wave form cannot be determined conveniently, a transformer having a rating of not less than ½ kVA at the usual breakdown voltage shall be used. Transformers of larger kilovolt-ampere capacity may be used, but in no case should the short-circuit current in the specimen circuit be outside the range of 1 to 10 mA/kV of applied voltage. This limitation of current may be accomplished by the use of a suitable external series resistor or by the designed reactance of the transformer.

4.2 *Circuit-Interrupting Equipment*—The test transformer primary circuit shall be protected by an automatic circuit-breaking device capable of opening in 3 cycles or less on the current produced by breakdown of the test specimen. A 5-cycle breaker may be used if the short-circuit current as described in 4.1 does not exceed 0.2 A. The current-sensing element that trips the circuit breaker should operate when the specimen-circuit current is in the range of 2 to 20 mA. A prolonged flow of current at the time of breakdown causes carbonization of the liquid and pitting and heating of the electrodes, and thereby increases the electrode and test cup maintenance and time of testing.

4.3 *Voltage-Control Equipment*—The rate of voltage rise shall be 3 kV/s ±20 %. Voltage control may be secured by a motor-driven variable-ratio-autotransformer. Preference should be given to equipment having an approximately straight-line voltage-time curve over the desired operating range. Motor drive is preferred to manual drive because of the difficulty of maintaining a reasonably uniform rate-of-voltage rise with the latter. The rate-of-voltage rise may be calculated from measurements of the time required to raise the voltage between two prescribed values. When motor-driven equipment is used, the speed control rheostat should be calibrated in terms of rate-of-voltage rise for the test transformer used.

4.4 *Voltmeter*—The voltage shall be measured by a method that fulfills the requirements of IEEE Standard No. 4, giving rms values, preferably by means of:

4.4.1 A voltmeter connected to the secondary of a separate potential transformer, or

4.4.2 A voltmeter connected to a well-designed tertiary coil in the test transformer, or

4.4.3 A voltmeter connected to the low-voltage side of the testing transformer if the measurement error can be maintained within the limit specified in 4.5.

4.5 *Accuracy*—The combined accuracy of the voltmeter and voltage divider circuit should be such that measurement error does not exceed 5 % at the rate-of-voltage rise specified in 4.3.

5. Electrodes

5.1 The electrodes shall be polished brass disks 25 mm or 1 in. in diameter, and at least 3 mm or ⅛ in. thick, with square edges.

6. Test Cup

6.1 A test cup having rigidly mounted electrodes with parallel faces and axes in a coincident horizontal line shall be used. The cup shall be constructed so that no part of it is less than 13 mm or ½ in. from any part of the test electrode disk. The total leakage and charging current of the cup, when filled with a good grade of oil, shall be less than 200 μA at 20 kV, 60 Hz. It shall be made of a material of high dielectric strength, and shall not be attacked by any of the cleaning or test liquids. It shall not absorb moisture or the cleaning and test liquids. The top of the cup should be at least 25 mm or 1 in. above the top of the electrodes. The cup

shall be designed to permit easy removal of the electrodes for cleaning and polishing, and to permit easy adjustment of the gap spacing.

7. Adjustment and Care of Electrodes and Test Cup

7.1 *Electrode Spacing*—The spacing of the electrodes during tests shall be 2.5 mm or 0.100 in. This shall be determined with a standard round gage of 2.5 ± 0.01 mm or 0.100 ± 0.0005 in., or flat steel "go" and "no-go" gages having thicknesses of 2.49 and 2.51 mm or 0.0995 and 0.1005 in., respectively. The spacing shall be rechecked following any polishing, wiping, or cleaning operation in which the cup is disassembled or the electrodes disturbed, and at the beginning of each day's testing.

7.2 *Cleaning*—The electrodes and the cup shall be wiped clean with dry, lint-free tissue paper or a clean dry chamois. It is important to avoid touching the electrodes or the cleaned gage with the fingers or with portions of the tissue paper or chamois that have been in contact with the hands. After adjustment of the gap spacing, the cup shall be rinsed with a dry hydrocarbon solvent, such as kerosine or Stoddard solvent.[5] A low-boiling solvent should not be used as its rapid evaporation may cool the cup, causing moisture condensation. If this occurs, the cup should be warmed slightly to evaporate the moisture before using it. Care shall be taken to avoid touching the electrodes or the inside of the cup after cleaning. After thorough cleaning, the cup shall be flushed with new, dry, filtered liquid of the type being tested, (preferably degassed oil if the cup is being used for testing oils). A voltage breakdown test shall be made on a sample of this liquid in the manner specified in this method. If the breakdown voltage is in the proper range for liquid in this good condition, the test cup shall be considered as properly prepared for testing other samples. If a lower value is obtained, the cup shall again be thoroughly cleaned and the test repeated with a clean dry liquid.

7.3 *Daily Use*—At the beginning of each day's testing, the electrodes shall be examined for pitting and contamination. They should be repolished if pitting is severe. Carbon or dirt should be wiped off, and the gap setting checked. The cup shall be flushed, and tested with a clean dry liquid as described in 7.2.

7.4 *Polishing of Electrodes*—When examination of electrodes shows minor scratching or pitting, the electrodes should be removed from the test cup and polished by buffing with jeweler's rouge using a soft cloth or soft buffing wheel. (Resurfacing may be necessary in order to remove deep pit marks or edge damage.) Care must be taken in resurfacing or in polishing to ensure that the electrode faces remain perpendicular to the axis and that the edges do not become rounded. All residue from the buffing must be removed before the electrodes are reinstalled in the test cup. This can be accomplished by repeated wiping with lint-free tissue paper saturated with a suitable solvent (such as petroleum ether), followed by solvent rinsing or ultrasonic cleaning. After the electrodes have been reinstalled in the test cup, clean and adjust spacing in accordance with 7.1 and 7.2.

7.5 *Storage of Test Cup*—When not in use, the cup, if used for referee tests, shall be stored filled with a new, dry, filtered liquid of the type being tested, and tightly covered.

8. Sampling

8.1 A sample of the liquid to be tested shall be obtained with the sampling apparatus applicable to the type of liquid as specified in accordance with Methods D 923. The sample shall be taken in a dry, clean bottle that shall be tightly sealed and shielded from light until ready to be tested (Note 1). Prior to starting the test, the sample shall be inspected for the presence of moisture, sludge, metallic particles, or other foreign matter. If the sample shows evidence of free water, the dielectric breakdown test may be waived, and the sample shall be reported as unsatisfactory.

NOTE 1—It is suggested that 2 L of sample be made available when referee tests are to be made, and 1 L of sample be made available when routine tests are to be made.

8.2 The dielectric breakdown voltage of liquids may be seriously impaired by the migration of impurities through the liquid. In order that a representative test specimen containing the impurities may be obtained, the sample container shall be gently inverted and swirled several times before filling the test cup. Rapid agitation is undesirable, since an excessive

[5] See ASTM Specification D 484, for Hydrocarbon Drycleaning Solvents, *Annual Book of ASTM Standards*, Vol 05.01.

amount of air may be introduced into the liquid. Immediately after agitation, a small portion of the sample shall be used to rinse the test cup. The cup shall then be filled slowly with the liquid to be tested in a manner that will avoid entrapment of air. It should be filled to a level not less than 20 mm or 0.8 in. above the top of the electrodes. In order to permit the escape of air, the liquid shall be allowed to stand in the cup for not less than 2 min and not more than 3 min before voltage is applied.

NOTE 2—It is impractical to handle liquids having viscosities ranging between 10 and 22 cSt (mm^2/s) (60 and 100 SUS) at 100°C (212°F) in the manner outlined in 8.2. When testing high-viscosity liquids in this range, the sample should be allowed to stand until it reaches room temperature, which should not be less than 20°C (68°F). The sample container should not be swirled as prescribed in 8.2, but should be inverted for at least 30 min before the test, and then reinverted and opened just prior to filling the test cup.

9. Test Temperature

9.1 The temperature of the specimen when tested shall be the same as that of the room, but the room temperature shall in no case be less than 20°C (68°F). Testing liquids at temperatures lower than that of the room will give variable and unsatisfactory results.

10. Rate of Rise of Voltage

10.1 Voltage shall be applied and increased from zero at the rate of 3 kV/s ± 20 % until breakdown occurs as indicated by operation of the circuit-interrupting equipment, and the value recorded. Occasional momentary discharges may occur which do not result in operation of the interrupting equipment, and shall be disregarded.

11. Procedure

11.1 *Referee Testing*—When it is desired to determine the dielectric breakdown voltage of a new liquid for referee purposes, one breakdown shall be made on each of five successive fillings of the test cup. The breakdown voltage thus obtained shall be subjected to the criterion for statistical consistency as specified in 11.3. If the five values meet this criterion, their average shall be reported as the dielectric breakdown voltage of the sample. If they do not meet this criterion, one breakdown on each of five additional cup fillings shall be made, and the average of the ten breakdowns shall be reported as the dielectric breakdown voltage of the sample. No breakdown shall be discarded.

11.2 *Routine Testing*—When it is desired to determine the dielectric breakdown voltage of a liquid on a routine basis, five breakdowns may be made on one cup filling with 1-min intervals between breakdowns. The average of the five breakdowns shall be considered the dielectric breakdown voltage of the sample, provided the breakdown values meet the criterion for statistical consistency as specified in 11.3. If the breakdown voltages do not meet this criterion, the contents of the cup shall be discarded, the sample container again gently inverted and swirled, the cup again filled, and five breakdowns made on this second cup filling. The average of the 10 breakdowns shall be considered as the dielectric breakdown voltage of the sample. No breakdown shall be discarded.

11.3 *Criterion for Statistical Consistency*—

11.3.1 Calculate the mean and standard deviation of the five breakdowns as follows:

$$\bar{x} = \tfrac{1}{5} \sum_{i=1}^{5} x_i \quad \text{and} \quad s = \sqrt{\tfrac{1}{4}\left(\sum_{i=1}^{5} x_i^2 - 5\bar{x}^2\right)}$$

where:

$\bar{x}$ = mean of the five individual values,
x_i = ith breakdown voltage, and
s = standard deviation.

If the ratio $s/\bar{x}$ exceeds 0.1, it is probable that the standard deviation of the five breakdowns is excessive, and therefore that the probable error of their average is also excessive.

11.3.2 *Alternative Criterion*—Calculate the range of the five breakdowns (maximum breakdown voltage minus minimum breakdown voltage), and multiply this range by three. If the value so obtained is greater than the next to the lowest breakdown voltage, it is probable that the standard deviation of the five breakdowns is excessive, and therefore the probable error of their average is also excessive.

12. Report

12.1 The report shall include the following:

12.1.1 ASTM designation of the test method used (D 877),

12.1.2 Procedure used, that is, referee test or routine test.

12.1.3 Approximate viscosity of the liquid tested,

12.1.4 Temperature of the liquid and the room at time of test, and

12.1.5 Individual breakdown values and the

average breakdown value in any of the following ways that may apply:

12.1.5.1 Five breakdowns, one on each of five cup fillings that meet the criterion of statistical consistency,

12.1.5.2 Ten breakdowns, one on each of ten cup fillings when the first five breakdowns do not meet the criterion for statistical consistency,

12.1.5.3 In routine testing, five breakdowns on one cup filling that meet the criterion of statistical consistency, or

12.1.5.4 When the routine test is employed, five breakdowns on each of two cup fillings when the breakdowns on the first cup filling do not meet the criterion of statistical consistency.

12.1.6 If the sample was observed to contain free water or other contaminants, the report should so indicate, with a statement that the test was not made.

13. Precision and Bias

13.1 The precision of this test method has not been determined. No statement can be made about the bias of this test method because a standard reference material is not available.

APPENDIX

(Nonmandatory Information)

X1. OTHER FACTORS THAT AFFECT THE DIELECTRIC BREAKDOWN VOLTAGE OF INSULATING LIQUIDS AT COMMERCIAL POWER FREQUENCIES

X1.1 The dielectric breakdown voltage of a liquid at commercial power frequencies is also affected by the degree of uniformity of the electric field, the area of the electrodes or volume of the liquid under maximum stress, the length of time for which the liquid is under stress, the temperature of the liquid (especially insofar as it affects the relative saturation level of moisture in solution), gassing tendencies of the liquid under the influence of electric stress, concentration of dissolved gases (especially if saturation levels are exceeded as a result of sudden cooling or decrease in pressure, which may cause the formation of gas bubbles), incompatibility with materials of construction, and velocity of flow. A decrease in dielectric strength of the liquid can have an accentuated effect on the electric creepage strength of solid insulating materials immersed in the liquid.

X1.2 Because of the separate, cumulative, and in some cases, interacting effects of the influences listed above, the average breakdown voltage of a liquid as determined by this test method cannot be used for design purposes. Alternative test procedures that may yield more meaningful indications of the functional dielectric strength of a liquid are under consideration (for example, a step-by-step method of applying voltage, and using the lowest rather than the average value of breakdown voltage obtained in the prescribed number of tests).

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

Designation: D 1816 – 84a

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Standard Test Method for DIELECTRIC BREAKDOWN VOLTAGE OF INSULATING OILS OF PETROLEUM ORIGIN USING VDE ELECTRODES[1]

This standard is issued under the fixed designation D 1816; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the dielectric breakdown voltage of insulating oils of petroleum origin. This test method is applicable to liquid petroleum oils commonly used in cables, transformers, oil circuit breakers, and similar apparatus as an insulating and cooling medium. The suitability of this test method for testing oils having viscosities of more than 19 cSt (mm^2/s) (100 SUS) at 40°C (104°F) has not been determined.

1.2 This test method is more sensitive to the deleterious effects of moisture in solution than is Test Method D 877, especially when cellulosic fibers are present in the oil. It has been found to be especially useful in diagnostic and laboratory investigations of the dielectric breakdown strength of oil in insulating systems.

1.3 This test method is recommended for testing filtered, degassed, and dehydrated oil prior to and during the filling of power systems apparatus rated above 230 kV, and for testing samples of oil from the apparatus after filling. It is also finding increased usage for testing oils from transformers in service.

1.4 This test method is not recommended for, and should not be used for, acceptance tests on oil received from vendors in tank cars, tank trucks, or drums.

1.5 Both the metric and the alternative inch-pound units are acceptable.

1.6 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Applicable Documents

2.1 *ASTM Standards:*

D 235 Specification for Mineral Spirits (Petroleum Spirits) (Hydrocarbon Dry-cleaning Solvent)[2]

D 877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes[3]

D 923 Methods of Sampling Electrical Insulating Liquids[3]

2.2 *IEEE Standard:*[4]

No. 4 Measurement of Voltage in Dielectric Test

3. Significance and Use

3.1 The dielectric breakdown voltage of an insulating liquid is of importance as a measure of the liquid's ability to withstand electric stress without failure. It serves to indicate the presence of contaminating agents such as water, dirt, moisture cellulosic fibers, or conducting particles in the liquid, one or more of which may be present in significant concentrations when low breakdown voltages are obtained. However, a high dielectric breakdown voltage does not necessarily indicate the absence of all contaminants; it may merely indicate that the concentrations of contaminants that are present in the liquid between the electrodes are not

[1] This test method is under the jurisdiction of ASTM Committee D-27 on Electrical Insulating Liquids and Gases and is the direct responsibility of Subcommittee D27.05 on Electrical Tests.

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[2] *Annual Book of ASTM Standards*, Vol 06.03.

[3] *Annual Book of ASTM Standards*, Vol 10.03.

[4] Available from the Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th St., New York, NY 10017.

large enough to affect deleteriously the average breakdown voltage of the liquid when tested by this test method (see Appendix X1.)

4. Apparatus

4.1 *Transformer*—The desired test voltage may be most readily obtained by a step-up transformer energized from a variable low-voltage commercial power frequency source. To reduce the likelihood of external flashover and to minimize field distortion between the electrodes, a two-bushing, center-tap-grounded transformer is recommended. The transformer and controlling element shall be of such size and design that, with the test specimen in the circuit, the crest factor (ratio of maximum to mean effective) of the 60-Hz test voltage shall differ by not more than ±5 % from that of a sinusoidal wave over the upper half of the range of test voltage. The crest factor may be checked by means of an oscilloscope, a spheregap, or a peak-reading voltmeter in conjunction with an rms voltmeter. Where the wave form cannot be determined conveniently, a transformer having a rating of not less than ½ kVA at the usual breakdown voltage shall be used. Transformers of larger kVA capacity may be used, but in no case should the short-circuit current in the specimen circuit be outside the range from 1 to 10 mA/kV of applied voltage. This limitation of current may be accomplished by using a suitable external series resistor or by employing a transformer with sufficient inherent reactance.

4.2 *Circuit-Interrupting Equipment*—The test transformer primary circuit shall be protected by an automatic circuit-breaking device capable of opening in 3 cycles or less on the current produced by breakdown of the test specimen, or up to 5 cycles if the short-circuit current as described in 4.1 does not exceed 200 mA. The current-sensing element that trips the circuit-breaker should operate when the specimen-circuit current is in the range from 2 to 20 mA. A prolonged flow of current at the time of breakdown causes carbonization of the liquid and pitting and heating of the electrodes, and thereby increases the electrode and test cell maintenance, and time of testing.

4.3 *Voltage-Control Equipment*—The rate of voltage rise shall be ½ kV/s ± 20 %. The rate-of-rise may be calculated from measurements of the time required to raise the voltage between two prescribed values. Voltage control may be secured by a motor-driven variable-ratio-autotransformer. Preference should be given to equipment having an approximate straight-line voltage-time curve over the desired operating range. Motor drive is preferred to manual drive because of the ease of maintaining a reasonably uniform rate-of-voltage rise with this test method. When motor driven equipment is used, the speed control rheostat should be calibrated in terms of rate-of-voltage rise for the test transformer used.

4.4 *Voltmeter*—The voltage shall be measured by a method that fulfills the requirements of IEEE Standard No. 4, giving rms values, preferably by means of:

4.4.1 A voltmeter connected to the secondary of a separate potential transformer, or

4.4.2 A voltmeter connected to a well-designed tertiary coil in the test transformer, or

4.4.3 A voltmeter connected to the low-voltage side of the testing transformer if the measurement error can be maintained within the limit specified in 4.5.

4.5 *Accuracy*—The combined accuracy of the voltmeter and voltage divider circuit should be such that measurement error does not exceed 5 % at the rate-of-voltage rise specified in 4.3.

5. Electrodes

5.1 The electrodes shall be polished brass spherically-capped electrodes of the VDE (Verband Deutscher Elektrotechniker, Specification 0370) type having the dimensions shown in Fig. 1. They shall be mounted with axes horizontal and coincident.

5.2 The test cell shall be designed to permit easy removal of the electrodes for cleaning and polishing.

6. Test Cell

6.1 The test cell shall be approximately cubical. A cell having a capacity of approximately 0.95 L, has been found to be satisfactory for an electrode spacing of 2 mm or 0.080 in. A cell having a capacity of approximately 0.5 L has been found to be satisfactory for an electrode spacing of 1 mm or 0.040 in. Electrodes shall be mounted rigidly from opposite sides with the gap approximately centered. Clearance from all other sides and any part of the stirring device shall be at least 13 mm (½ in.). The test cell shall be provided with a motor-driven two-bladed impeller measuring approximately 35 mm (1⅜ in.) between the blade extremities,

having a pitch of approximately 40 mm or 1.57 in. (blade angle of approximately 20°), operating at a speed between 200 and 300 rpm. The impeller, located below the lower edge of the electrodes, shall rotate in such a direction that the resulting liquid flow is directed downward against the bottom of the test cell. The test cell shall be made of a material of high dielectric strength, shall be insoluble in and unattacked by any of the cleaning or test liquids used, and shall be nonabsorbent to moisture and the cleaning and test liquids. So the breakdown may be observed, transparent materials are desirable, but not essential. In order to preclude stirring air with the sample, the cell should be provided with a cover or baffle that will effectively prevent air from contacting the circulating liquid.

7. Adjustment and Care of Electrodes and Test Cell

7.1 *Spacing*—With the electrodes firmly locked in position, the electrodes shall be checked with a standard round gage for 2-mm or 0.080-in. spacing, when a voltage source of a suitable range is available, or for 1-mm or 0.040-in. spacing when the test transformer voltage limit is restricted to approximately 50 kV. Flat "go" and "no-go" gages may be substituted having thicknesses of the specified value ±0.03 mm for electrode spacings of 1 or 2 mm, or thicknesses of the specified value ±0.001 in. for spacings of 0.040 or 0.080 in. If it is necessary to readjust the electrodes, they shall be relocked, and the spacing again checked.

7.2 *Cleaning*—The electrodes and the cell shall be wiped clean with dry, lint-free tissue paper, or a clean dry chamois. It is important to avoid touching the electrodes or the cleaned gage with the fingers or with portions of the tissue paper or chamois that have been in contact with the hands. After adjustment of the gap spacing, the cell shall be rinsed with a dry hydrocarbon solvent, such as kerosine or solvents of Specification D 235. A low-boiling solvent should not be used, as its rapid evaporation may cool the cell, causing moisture condensation. If this occurs, before using, the cell should be slightly warmed to evaporate the moisture. Care shall be taken to avoid touching the electrodes or the inside of the cell after cleaning. After thorough cleaning, the cell shall be flushed with new, dry, filtered oil of the type to be tested (preferably degassed oil). A voltage breakdown test shall be made on a sample of this oil in the manner specified in this test method. If the breakdown voltage is in the proper range for this conditioned oil, the cell shall be considered as properly prepared for testing other samples. A lower than anticipated value shall be considered as evidence of cell contamination, and it shall again be thoroughly cleaned, and the breakdown test repeated with a clean dry oil.

7.3 *Daily Use*—At the beginning of each day's testing, the electrodes shall be examined for pitting and carbon accumulation, and the spacing checked. If the test of any sample is below the breakdown value being used by the operator as a minimum satisfactory value, the cell shall be drained and flushed with a good quality oil of the type being tested before testing the next sample. When not in use, the cell shall be kept filled with good quality oil of the type normally tested.

7.4 *Polishing of Electrodes*—When electrodes show slight etching, scratching, pitting, or carbon accumulation, they should be removed from the test cup and polished by buffing with jeweler's rouge using a soft cloth or soft buffing wheel. The residue from the buffing should be removed by repeated wiping with lint-free tissue paper saturated with a suitable solvent (such as petroleum ether), followed by solvent rinsing or ultrasonic cleaning. After careful inspection, any electrodes from which pitting cannot be removed by light buffing should be discarded or refinished to the original contour and finish, as more severe refinishing would destroy the electrode contour and dimensions shown in Fig. 1. Reinstall the electrodes in the test cup and adjust spacing and clean in accordance with 7.1 and 7.2.

8. Sampling

8.1 A sample of the oil to be tested shall be obtained with appropriate ASTM sampling apparatus. Oil sampling procedures are detailed in Methods D 923. Particular reference should be made to the general precaution statement of this test method. The sample shall be taken in a dry, clean bottle which shall be tightly sealed and shielded from light until ready to be tested.

8.2 The dielectric breakdown voltage of liquids may be seriously impaired by the migra-

tion of impurities through the liquid. In order that a representative test specimen containing the impurities may be obtained, the sample container shall be gently inverted and swirled several times before filling the test cell. Rapid agitation is undesirable, since an excessive amount of air may be introduced into the liquid. Immediately after agitation, a small portion of the sample shall be used to rinse the test cell. The cell shall then be filled slowly with the remaining portion of the sample. There shall be an interval of at least 3 min between filling and application of voltage for the first breakdown, and at least 1-min intervals before applications of voltage for successive breakdowns. During these intervals and at the time voltage is being applied, the propeller shall be circulating the oil.

9. Test Temperature

9.1 The temperature of the sample when tested shall be the same as that of the room, but the room temperature shall in no case be less than 20°C (68°F). Testing liquids at temperatures lower than that of the room may give variable and unsatisfactory results.

10. Procedure

10.1 *Rate-of-Rise of Voltage*—Apply the voltage and increase from zero at the rate of approximately ½ kV/s until breakdown occurs, as indicated by operation of the circuit-interrupting equipment; record the value. Occasional momentary discharges may occur which do not result in operation of the interrupting equipment; these shall be disregarded.

10.2 When it is desired to determine the value of the dielectric breakdown voltage of an oil, make five breakdowns on one filling of the cup. Examine the five breakdowns for statistical consistency, and if they meet the criterion described in 10.3, use their average to determine the dielectric breakdown voltage of the sample. If they do not meet this criterion, make five additional breakdowns on the sample, and use the average of all ten breakdowns as the dielectric breakdown voltage of the sample.

10.3 *Criterion for Statistical Consistency:*

10.3.1 Calculate the mean and standard deviation of the five breakdowns as follows:

$$\bar{X} = \tfrac{1}{5} \sum_{i=1}^{5} X_i \text{ and } s = \sqrt{\tfrac{1}{4}[\sum_{i=1}^{5} X_i^2 - 5\bar{X}^2]}$$

where:

$\bar{X}$ = mean of the five individual values,
X_i = ith breakdown voltage, and
s = standard deviation.

If the ratio $s/\bar{X}$ exceeds 0.1, it is probable that the standard deviation of the five breakdowns is excessive and therefore that the probable error of their average is also excessive.

10.3.2 *Alternative Criterion*—Calculate the range of the five breakdowns (maximum breakdown voltage minus minimum breakdown voltage), and multiply this range by three. If the value so obtained is greater than the next to the lowest breakdown, it indicates that the standard deviation of the five breakdowns, and, therefore, the probable error of their average value, is excessive.

10.4 When it is desired merely to determine if the dielectric strength is above or below a specified level, only five breakdowns are required, provided the five values are all above or all below this level. Otherwise, follow the procedure described in 10.2.

11. Report

11.1 The report shall include the following:

11.1.1 The test method used,

11.1.2 If the number of tests are as specified in 10.2, the volts (rms value) at each breakdown, and the average of all breakdowns reported to the nearest 1 kV,

11.1.3 If the test is made in accordance with 10.4, the report shall be made in one of the following ways:

11.1.3.1 "Passed" if all of the five breakdowns were above a previously established value,

11.1.3.2 "Failed" if all of the five breakdowns were below a previously established value,

1.1.3.3 "Not less than the minimum of the five breakdowns" if all were above a previously established value, or

11.1.3.4 "Not greater than the maximum of the five breakdowns" if all were below a previously established value.

11.1.4 The approximate temperature of the oil at the time of the test, and

11.1.5 The electrode spacing.

12. Precision and Bias

12.1 The precision of this test method has not been determined. No statement can be made about the bias of this test method because a standard reference material is not available.

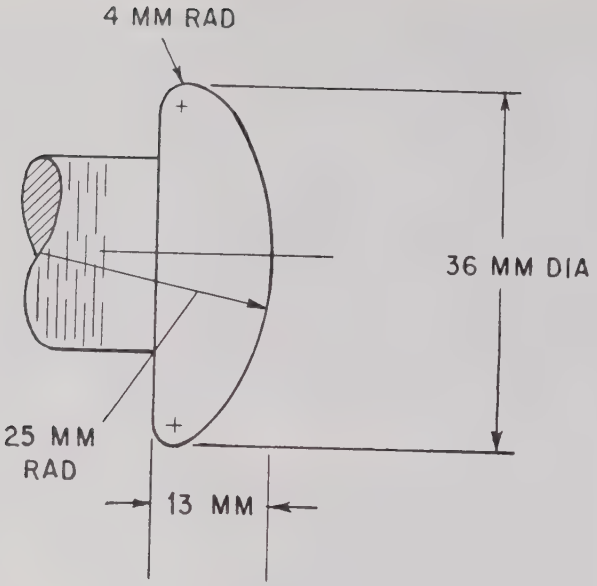


FIG. 1 VDE Electrode

APPENDIX

(Nonmandatory Information)

X1. OTHER FACTORS THAT AFFECT THE DIELECTRIC BREAKDOWN VOLTAGE OF INSULATING LIQUIDS AT COMMERCIAL POWER FREQUENCIES

X1.1 The dielectric breakdown voltage of a liquid at commercial power frequencies is also affected by the degree of uniformity of the electric field, the area of the electrodes or volume of the liquid under maximum stress, the length of time for which the liquid is under stress, the temperature of the liquid (especially as it affects the relative saturation level of moisture in solution), gassing tendencies of the liquid under the influence of electric stress, concentration of dissolved gases (especially if saturation levels are exceeded as a result of sudden cooling or decrease in pressure, which may cause the formation of gas bubbles), incompatibility with materials of construction, and velocity of flow. A decrease in dielectric strength of the liquid can have an accentuated effect on the electric creepage strength of solid insulating materials immersed in the liquid.

X1.2 Because of the separate, cumulative, and in some cases, interacting effects of the influences listed above, the average breakdown voltage of a liquid as determined by this test method cannot be used for design purposes. Alternative test procedures that may yield more meaningful indications of the functional dielectric strength of a liquid are under consideration (for example, a step-by-step method of applying voltage, and using the lowest rather than the average value of breakdown voltage obtained in the prescribed number of tests).

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.

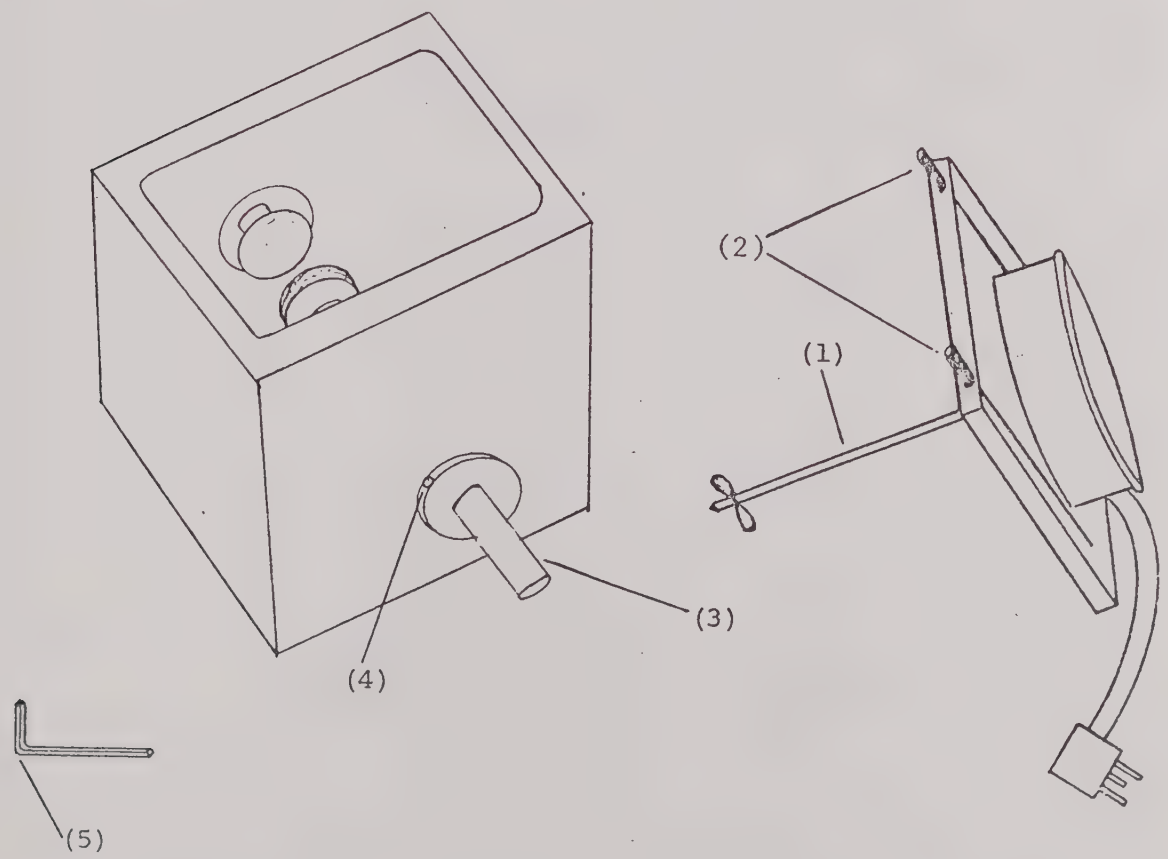
HIPOTRONICS

TC/VDE TEST CELL

The HIPOTRONICS TC/VDE Test Cell (oil cup) has been designed to determine the dielectric strength of insulating liquids in conjunction with HIPOTRONICS portable Liquid Dielectric Testers OC-50A, OC-60A and OC-51M.

The TC/VDE Test Cell is equipped with a motor-driven circulator (1), 0.080-inch and 0.040-inch gap gauges (2), and two VDE electrodes, one of which (3) is adjustable and may be fixed to provide the desired gap via a set screw (4). An Allen wrench (5) is supplied for the set screw.

The TC/VDE Test Cell is engineered specifically for testing at 500 volts per second in accordance with ASTM Standard D1816-74, a copy of which is enclosed.



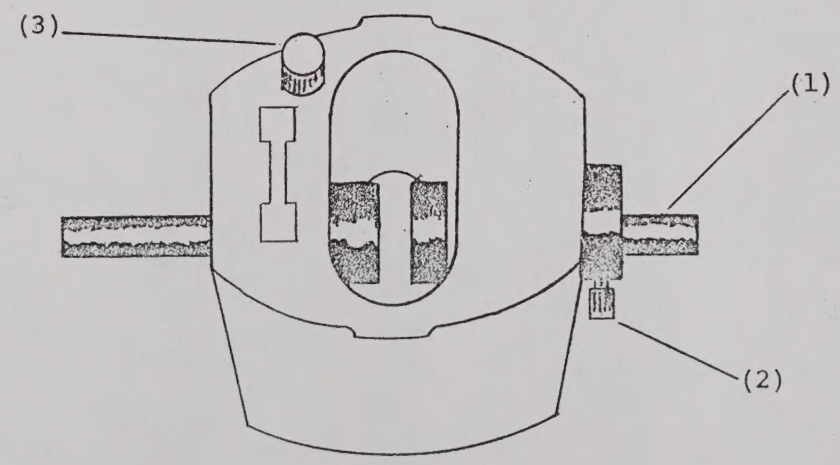
TC/VDE TEST CELL

TC/DE TEST CELL

The HIPOTRONICS TC/DE Test Cell (oil cup) has been designed to determine the dielectric strength of insulating liquids in conjunction with HIPOTRONICS portable Liquid Dielectric Testers OC-50A, OC-60A and OC-51M.

The TC/DE Test Cell is equipped with two one-inch diameter disc electrodes, one of which (1) is adjustable and may be fixed to provide the desired gap via a set screw (2). A standard 0.100-inch gap gauge (3) is supplied with the test cell.

The TC/DE Test Cell is engineered specifically for testing at 3,000 volts per second in accordance with ASTM Standard D877-67, a copy of which is enclosed.



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